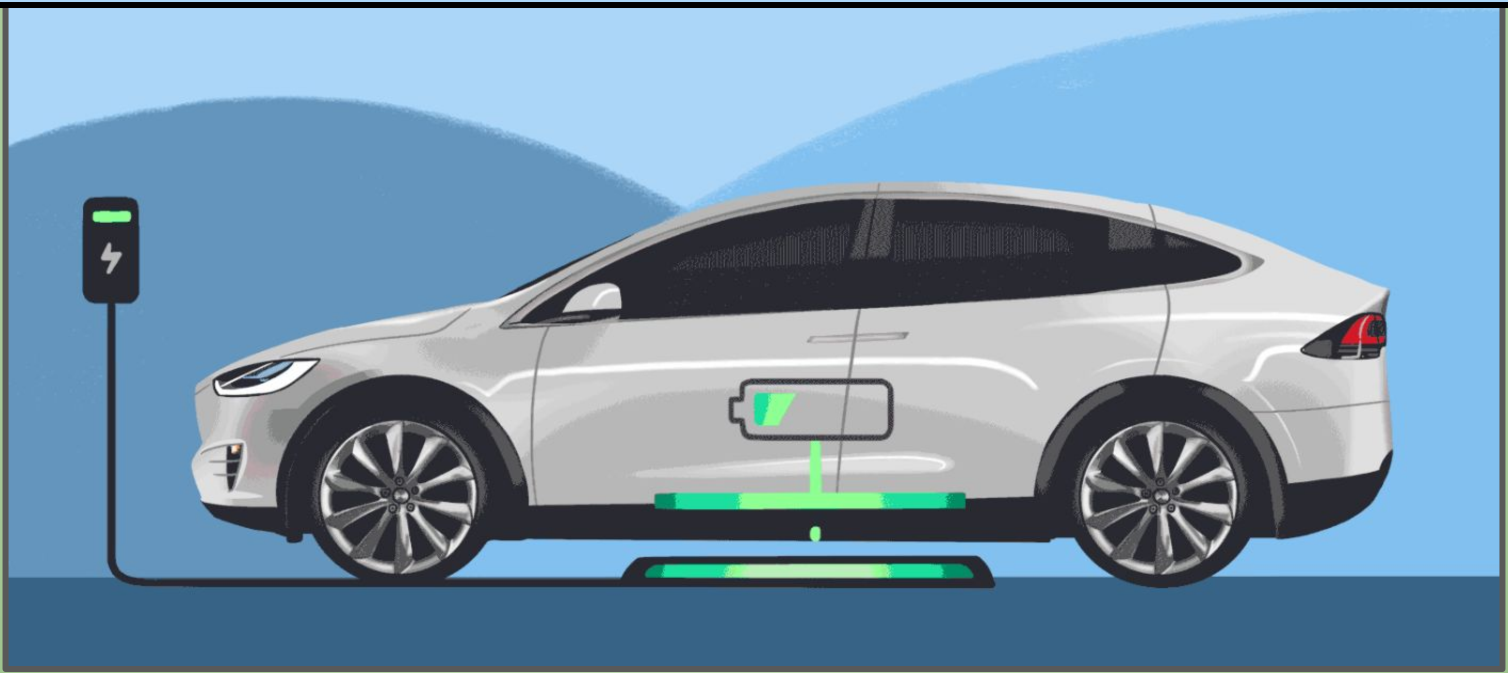
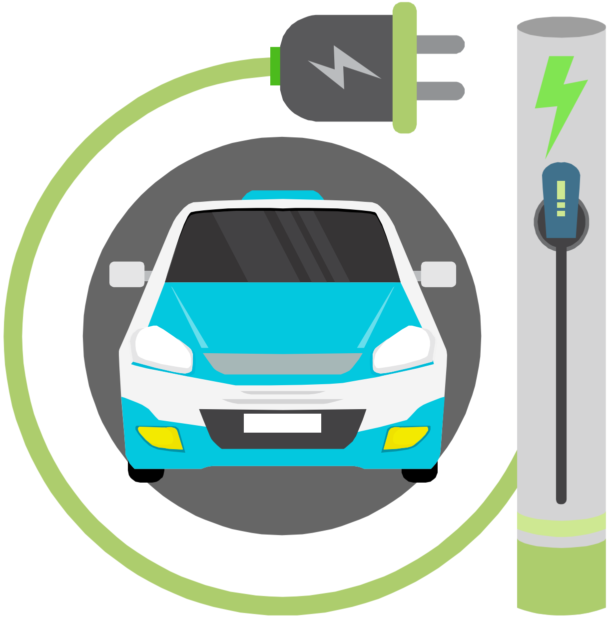
IoT-Based Wireless EV Charging System For Electric Vehicle



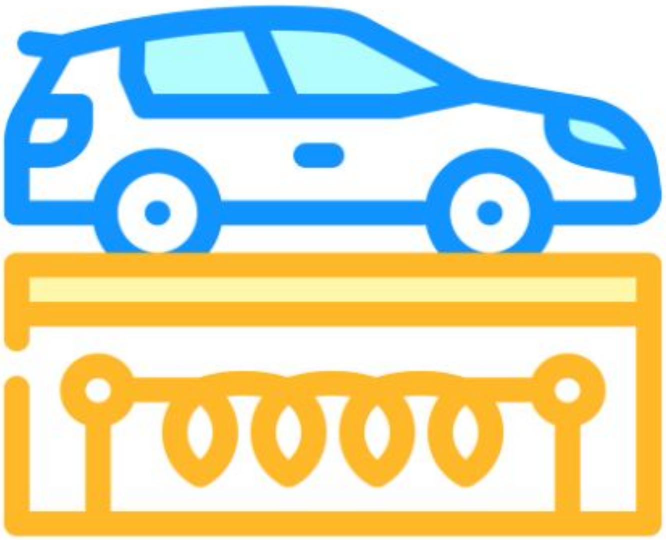
Problem Statement

The necessity for effective and practical charging infrastructure has arisen from the explosive expansion of electric cars (EVs) in recent years. Conventional plug-in charging techniques have drawbacks in terms of physical connector wear and tear, possible safety risks, and user convenience. Inductive power coil-based wireless charging systems have surfaced as a viable remedy for these issues.Nevertheless, there are a number of issues that need to be resolved when integrating Internet of Things (IoT) capabilities with inductive power coil-based wireless EV charging systems.



Introduction

This section provides an introduction to the project, covering its background, problem statement, motivation, potential beneficiaries, objectives, and scope. It delves into the project's inception, highlighting the critical need to address flooding through advanced technologies. The discussion touches on the diverse beneficiaries, including local communities, emergency responders, and government agencies. Objectives such as studying existing systems and developing advanced models are outlined, while the scope spans multiple domains, emphasizing the project's comprehensive approach.

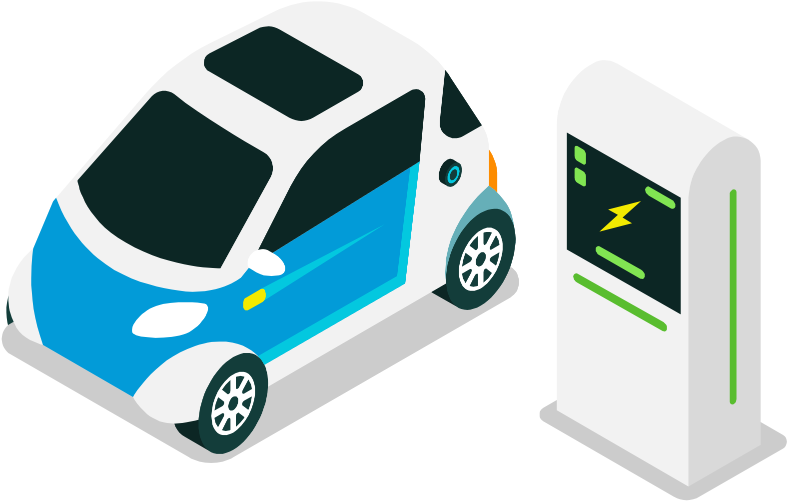


Objective

- To create a charging station capable of accommodating two electric vehicles simultaneously, thereby increasing charging capacity and efficiency to meet the growing demand for electric vehicle charging infrastructure.
- To integrate a user-friendly mobile application interface that allows users to remotely monitor, manage, and schedule charging sessions, providing convenience and flexibility while ensuring optimal utilization of charging resources.
- To implement power-saving mechanisms within the charging station, such as intelligent power management and scheduling algorithms, aimed at optimizing energy consumption and reducing environmental impact during the charging process.
- To develop and incorporate auto-detection technology that can automatically identify and adjust charging parameters based on the specific requirements of different electric vehicle models, ensuring compatibility and enhancing user experience.

Background

Growing concerns about crude oil depletion and environmental impact are driving a crucial shift towards alternative energy sources. Electric vehicles (EVs) are gaining prominence due to their environmental advantages, despite initial purchase costs. Major automotive manufacturers are transitioning to hybrid and all-electric models. However, successful EV market penetration requires robust battery charging infrastructure. Wireless Power Transfer (WPT) systems, especially Wireless Inductive Power Transfer (IPT), offer cable-free charging solutions with advantages spanning various applications. This includes mobile phones, biomedical implants, textiles, space technology, and military applications. The concept of a wireless charger for EVs, employing electromagnetic induction, is central. Nikola Tesla's century-old vision of inductive power transfer without a magnetic core inspires current advancements. The research focuses on midrange wireless transfer capabilities, emphasizing efficient wireless power transfer through factors like resonance frequency alignment and non-radiative magnetic coupling to reduce energy consumption for medium to long-range transmission.



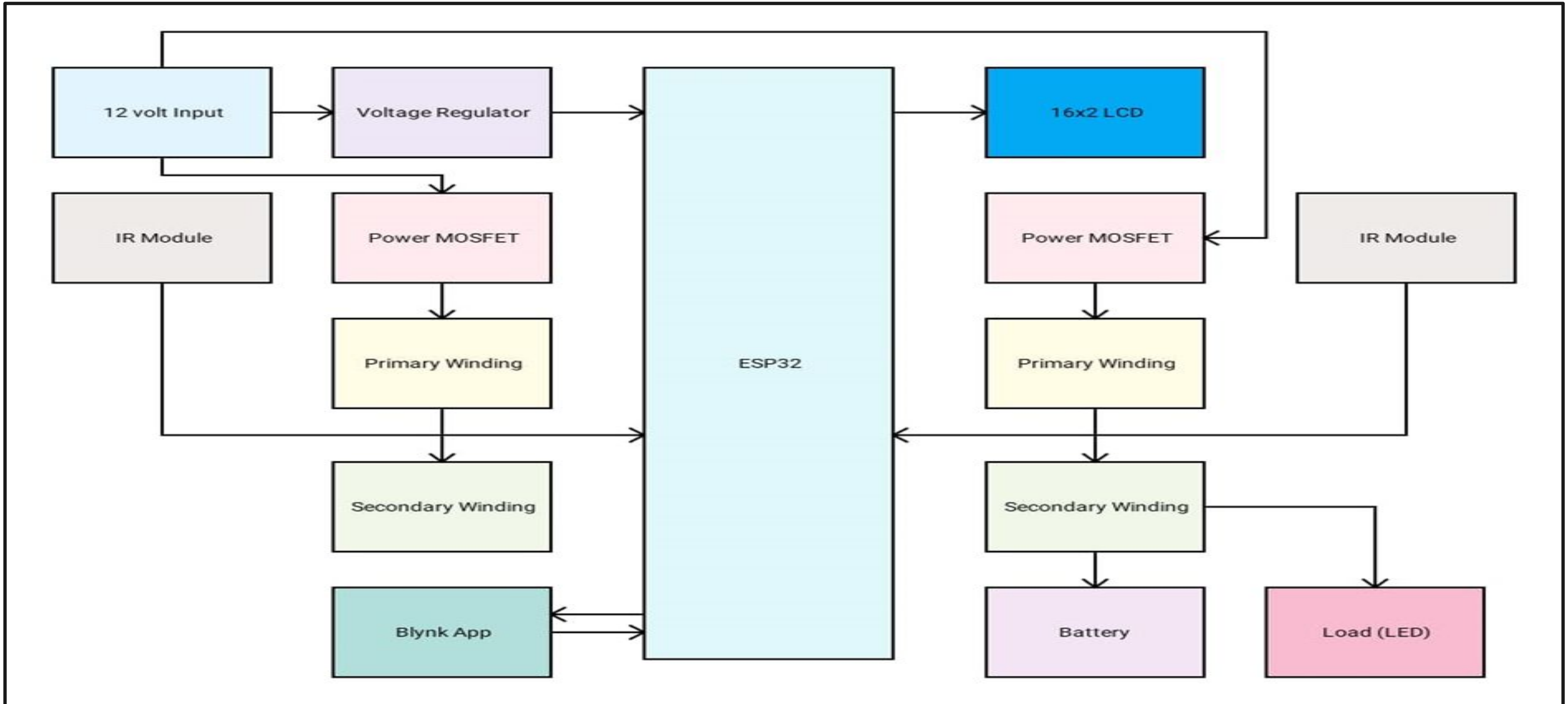
Need of project

The motivation behind this project stems from the evolving landscape of electric vehicle (EV) technology, which is experiencing a rapid surge in popularity. As the demand for EVs continues to grow, the necessity for efficient and user-friendly charging infrastructure becomes increasingly evident. The current state of affairs in EV charging stations primarily involves physical connections through cables, which possess inherent limitations in terms of user convenience, varying charging standards, and compatibility issues. Addressing these limitations, the endeavor to develop wireless EV charging technology emerges as a compelling solution. This project is motivated by the potential benefits that wireless charging offers, such as the ease of use without physical plugging, the promising prospect of automatic charging, and the elimination of dependency on charging cables. By exploring and advancing IoT-based wireless charging systems, the project aims to augment the existing EV ecosystem. This innovation intends to provide drivers with diverse and convenient charging options, both at home and on the go, thereby fostering the seamless integration of electric vehicles into everyday transportation while overcoming the constraints of traditional charging methods.

Methodology

The technology of wireless charging is one that is growing quickly and has attracted a lot of attention lately. Monitoring the charging process to guarantee effective and secure charging is one of the difficulties with wireless charging. The ESP32 module is a well-liked option for tracking wireless charging stations due to its low power consumption and wireless capabilities. We go over some of the most current research on ESP32-based wireless charging station monitoring in this overview of the literature. Research indicates that using the ESP32 module as a foundation for monitoring wireless charging stations is dependable and effective. To guarantee effective and secure charging, the ESP32 module offers real-time monitoring, data collecting, and feedback to the user. In order to maximise the functionality and performance of ESP32-based wireless charging stations and to investigate the range of possible uses for them, more study is required.

Design



12 volt Input
Voltage Regulator
ESP32
16x2 LCD
IR Module
Power MOSFET
Power MOSFET
IR Module
Primary Winding
Primary Winding
Secondary Winding
Secondary Winding
Blynk App
Battery
Load (LED)

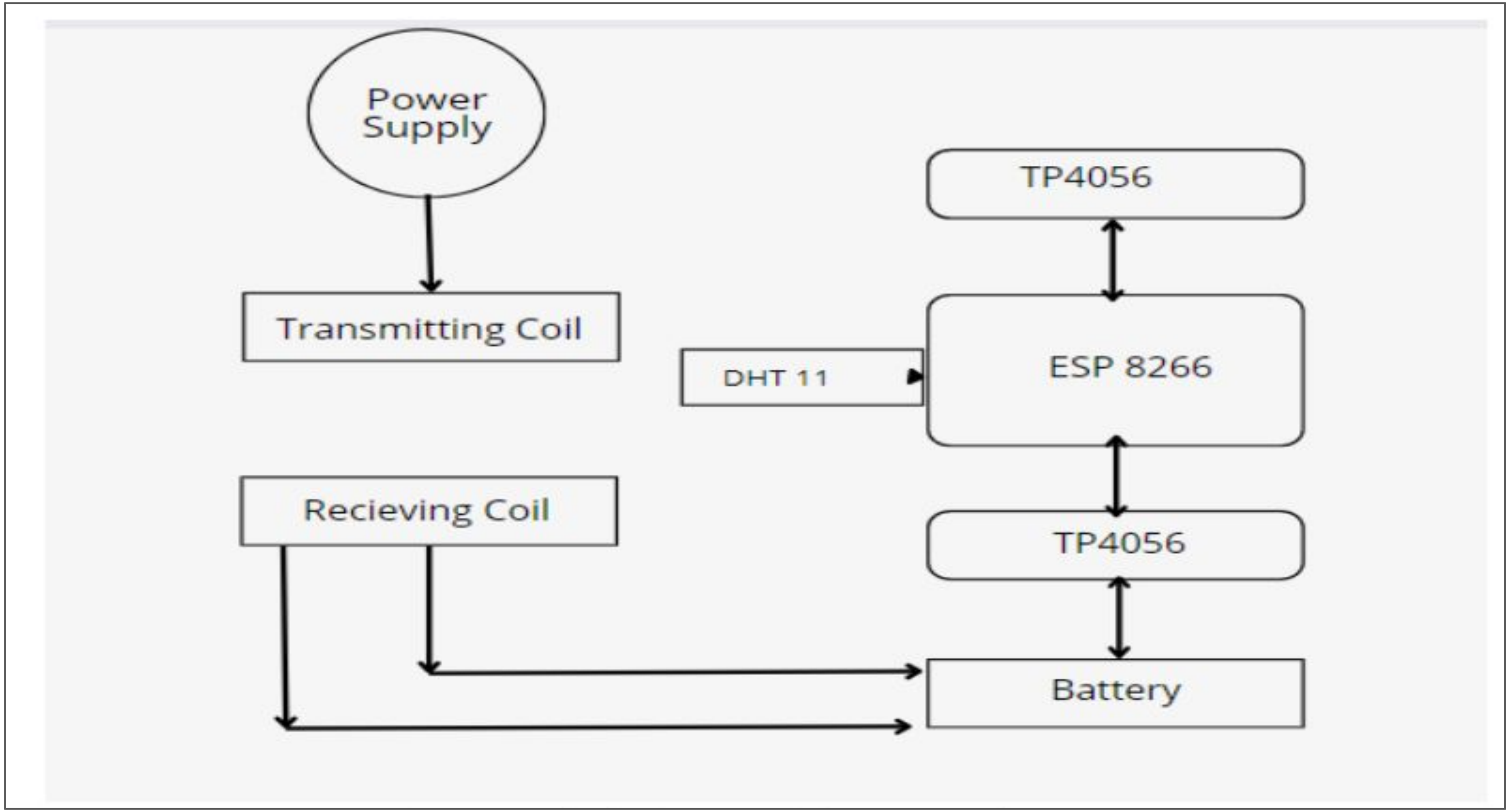


Figure 1: Block Diagram of the Proposed System

Designing an IoT-based wireless vehicle charging station with dual spots, app control, power saving, and auto-detection involves several components and functionalities:

- Wireless Charging Modules: These modules are the primary components responsible for wirelessly charging the vehicles. Each charging spot will have its own charging module.
- Vehicle Presence Detection: This component detects when a vehicle is present at the charging spot. It can utilize sensors such as infrared sensors or ultrasonic sensors to detect the presence of a vehicle.
- IoT Gateway: The IoT gateway acts as a bridge between the wireless charging station and the internet. It facilitates communication between the charging station and the cloud server.
- Cloud Server: The cloud server is responsible for storing data, managing user accounts, handling requests from the mobile app, and sending commands to the charging station.
- Mobile App Interface: The mobile app provides users with a user-friendly interface to monitor the charging status of their vehicles, initiate charging sessions, and configure settings such as charging schedules and notifications.
- Power Management System: This component optimizes power usage to ensure efficient charging while minimizing energy consumption and costs. It may include features such as power scheduling and load balancing.
- Auto Detection System: The auto-detection system automatically identifies compatible vehicles and adjusts the charging parameters accordingly. This ensures compatibility with a wide range of electric vehicles.

Designing an IoT-based wireless vehicle charging station with dual spots, app control, power saving, and auto-detection involves several components and functionalities:

- Safety Systems: Safety systems such as overcurrent protection, overvoltage protection, and temperature monitoring are essential to ensure safe charging operations and prevent damage to the vehicles and charging equipment.
- Dual Spot Configuration: The charging station is designed to accommodate two vehicles simultaneously, allowing for increased charging capacity and efficiency.
- App Control Interface: The mobile app provides users with the ability to control and monitor the charging process remotely. Users can start or stop charging sessions, monitor charging progress, and receive notifications.

Components Requirement:

- Arduino Nano: This will serve as the microcontroller for controlling and monitoring the charging process.
- Winding Wire (200g): This wire will be used to create the charging coil for each charging spot. It's essential for generating the alternating magnetic field necessary for wireless charging.
- Base Sheet (40x25cm): The base sheet provides the foundation for mounting the components and assembling the charging module.
- Resistor (5x): Resistors may be used for various purposes such as voltage division, current limiting, or as pull-up/pull-down resistors for digital inputs.
- Arduino USB Cable (1): This cable is used to connect the Arduino Nano to a computer for programming or debugging.
- General Purpose PCB (2 inch square): PCBs can be used for creating custom circuitry and mounting electronic components securely.
- Ribbon Wire (1 meter): Ribbon wire can be used for connecting various components on the PCB or for wiring purposes.
- Female Header (2x): Female headers are used for making connections between different components or modules.
- Male Header (2x): Male headers are complementary to female headers and are used for making connections.
- Load Wire (1 meter): This wire is likely used for connecting the charging coil to the power supply and other circuitry.

Components Requirement:

- Voltage Regulator (1): Voltage regulators are used to regulate the voltage supplied to different components of the circuit.
- Soldering Wire: Soldering wire is essential for soldering electronic components onto the PCB.
- White Paper (2 meter): White paper may be used for insulation or as a base layer for the charging coil.
- Base Sheet Stand (1): This stand provides support for the base sheet and helps elevate the charging module.
- Pot (1): Potentiometers can be used for analog control or as voltage dividers in the circuit.
- LCD 16x2 (1): LCD displays provide visual feedback to users about the charging status and other relevant information.
- Heat Sink (4x2 Inches): Heat sinks help dissipate heat generated by components such as voltage regulators or MOSFETs.
- Fitting Screws (10x): These screws are used for mounting components onto the base sheet or PCB.
- Double-sided Tape (1x): Double-sided tape can be used for securing components or mounting the charging module in place.
- Capacitor (1x): Capacitors may be used for smoothing out voltage fluctuations or filtering noise in the circuit.
- Diode (4x): Diodes are used for various purposes such as rectification, voltage clamping, or as protection diodes.

Components Requirement:

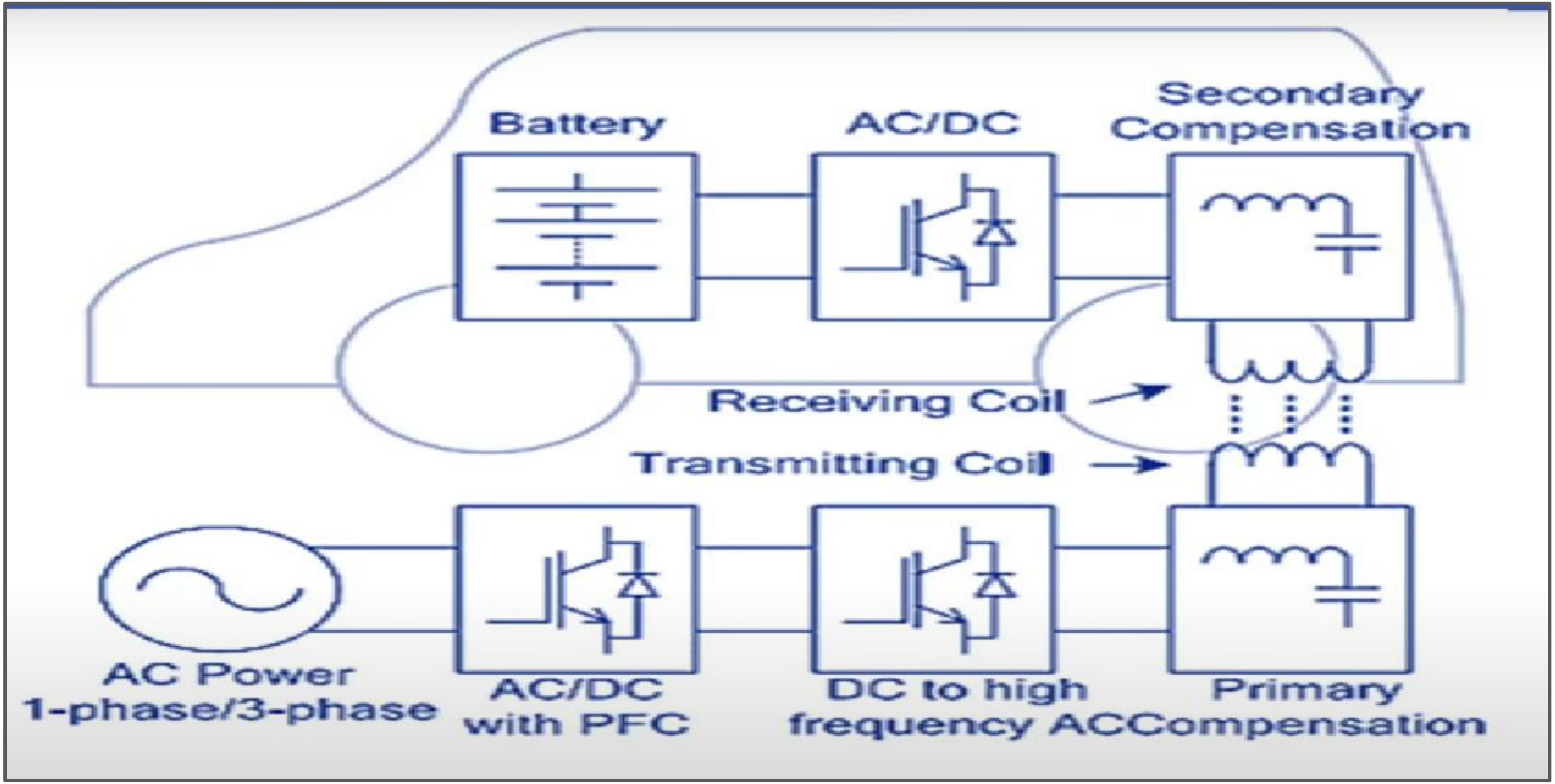
- Super Glue (1): Super glue can be used for securing components or assembling parts together.
- Power Socket (1): The power socket provides the interface for connecting the charging module to the power supply.
- MOSFET (2): MOSFETs are used as switches or amplifiers in the circuit, typically for controlling the charging process.
- Fitting Screws (10x): Additional fitting screws for mounting purposes.
- Double-sided Tape (1x): Additional double-sided tape for securing components.

48. IoT Based Wireless Vehicle Charging Station - Saved

Sr No.	Component Names	quantity
1	Arduino Nano	1
2	Winding Wire	200g
3	Base Sheet	40x25cm
4	Resistor	5x
5	Arduino USB cable	1
6	General Purpose PCB	2 inch square
8	Ribbon wire	1 meter
10	Female header	2x
11	Male header	2x
12	Load Wire	1 meter
13	Voltage regulator	1
14	Soldering Wire	2 meter
15	white paper	19x13 Inch
16	Base sheet Stand	6x
17	Pot	1
18	LCD 16x2	1
19	Heat Sink	4x2 Inches
20	Fitting Screws	10x
21	Double side Tap	1
22	Capacitor	1x
23	Diode	4x
24	super glue	1
25	Power Socket	1
26	MOSFET	2

Total Estimated Cost ≈ ₹16,200

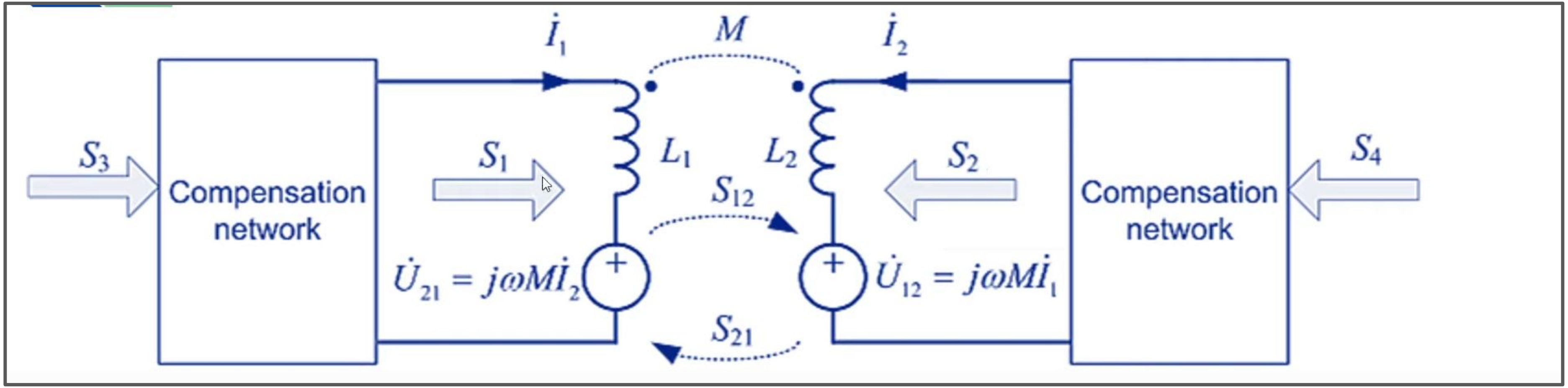
Typical Wireless EV charging system:



Typical Wireless EV charging system:

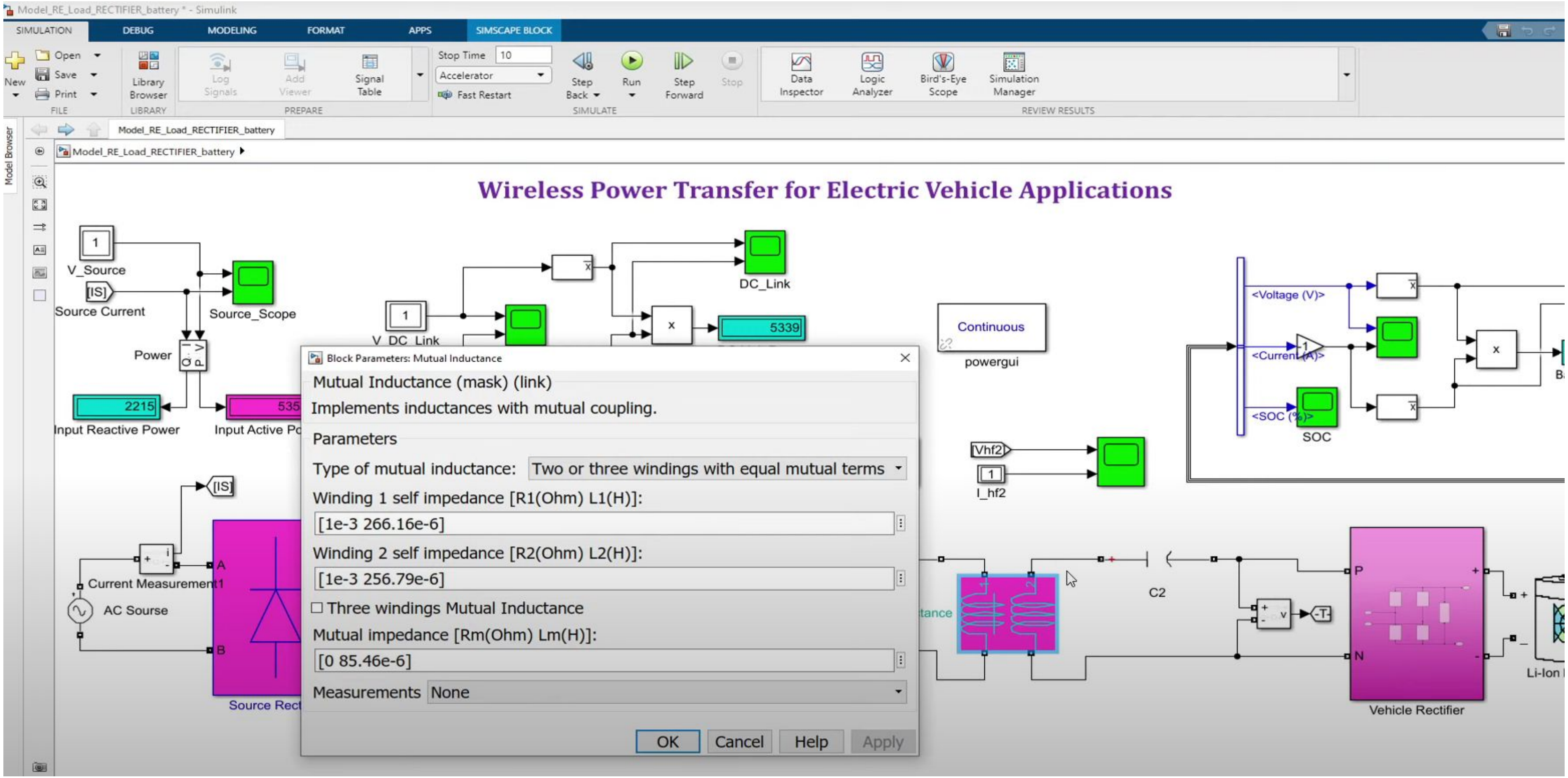
- Wireless power transfer (WPT) using magnetic resonance is the technology which could set human free from the annoying wires.
- The advances make the WPT very attractive to the electric vehicle (EV) charging applications in both stationary and dynamic charging scenarios.
- A typical wireless EV charging system is shown in Fig.
- It includes several stages to charge an EV wirelessly. First, the utility ac power is converted to a dc power source by an ac to dc converter with power factor correction.
- Then, the dc power is converted to a high-frequency ac to drive the transmitting coil through a compensation network.
- The high-frequency current in the transmitting coil generates an alternating magnetic field, which induces an ac voltage on the receiving coil. By resonating with the secondary compensation network, the transferred power and efficiency are significantly improved. At last, the ac power is rectified to charge the battery

Two Coil Wireless Power Transform System:

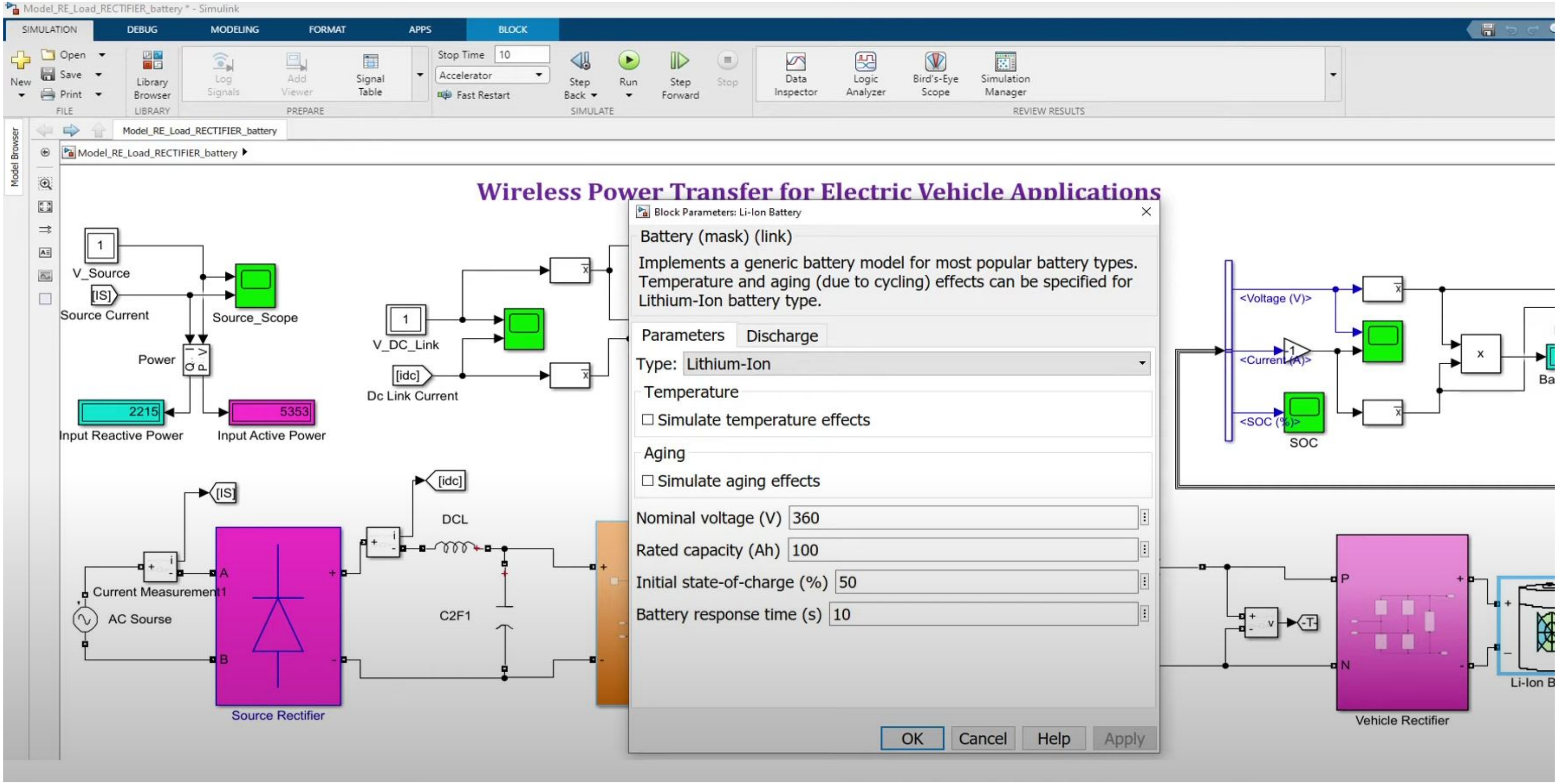


- L1 represents the self-inductance of the primary side transmitting coil and L2 represents the self-inductance of the receiving coil.
- S1 and S2 are the apparent power goes into L1 & L2.
- S3 and S4 are the apparent power provided by the power converter.
- S12 and S21 represent the apparent power exchange between the two coils.

Mutual Inductance:



Battery:


Model_RE_Load_RECTIFIER_battery * - Simulink
SIMULATION
DEBUG
MODELING
FORMAT
APPS
BLOCK
Open
Save
Print
New
FILE
Library Browser
LIBRARY
Log Signals
Add Viewer
Signal Table
PREPARE
Stop Time
10
Accelerator
Fast Restart
Step Back
Run
Step Forward
Stop
SIMULATE
Data Inspector
Logic Analyzer
Bird's-Eye Scope
Simulation Manager
REVIEW RESULTS
Model Browser
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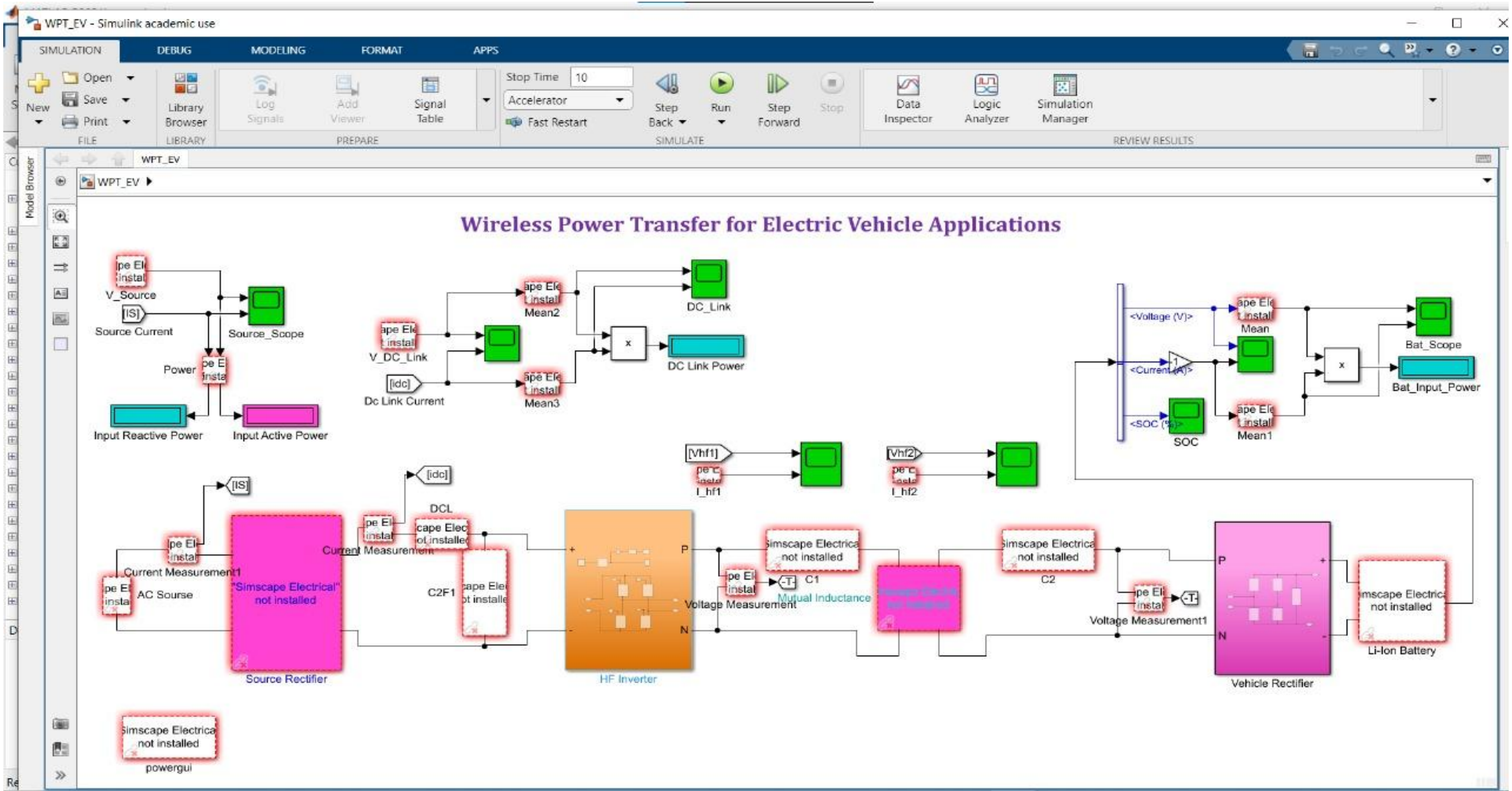
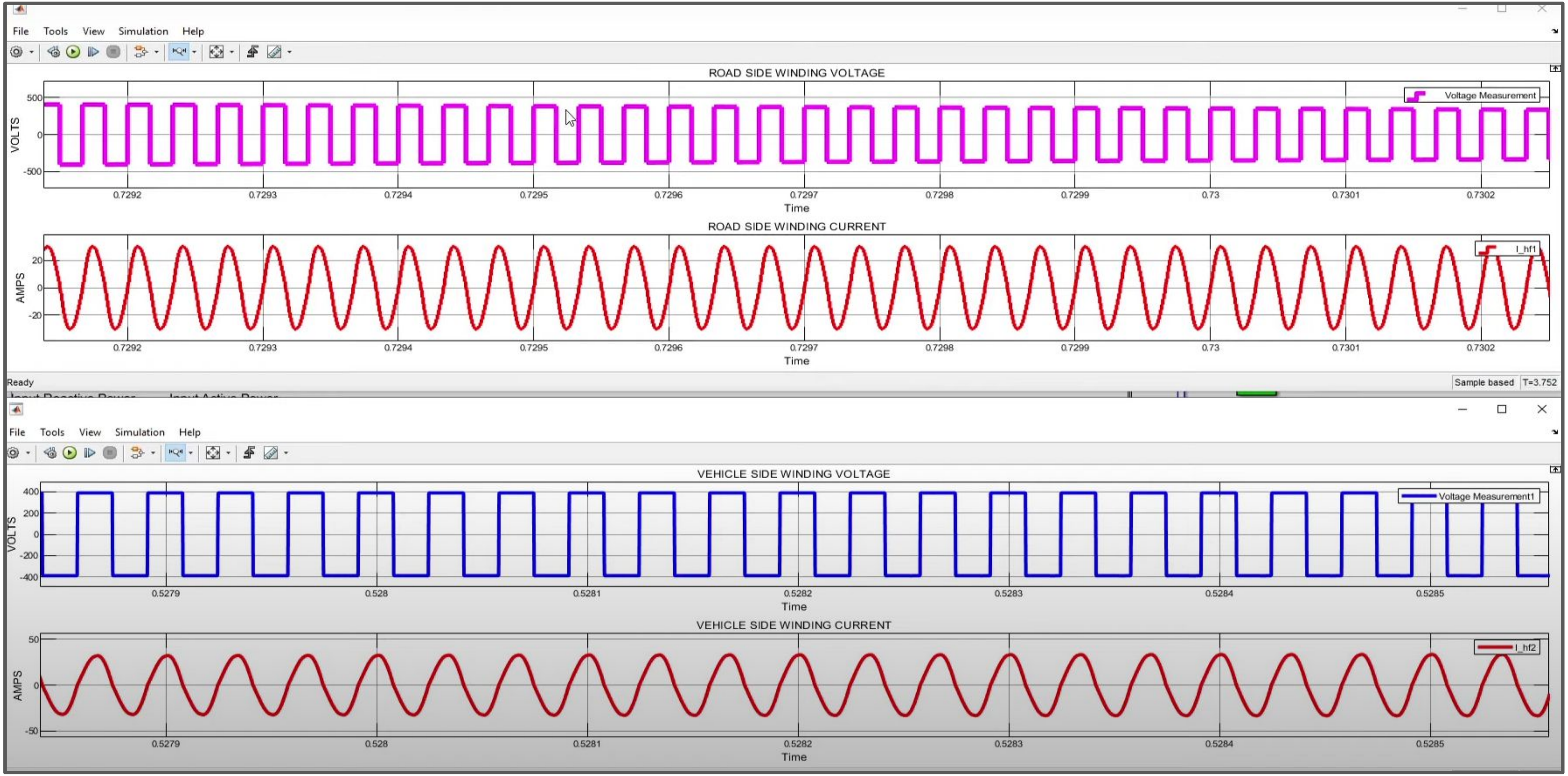
Wireless Power Transfer for Electric Vehicle Applications
1
V_Source
[IS]
Source Current
Source_Scope
Power
2215
Input Reactive Power
5353
Input Active Power
1
V_DC_Link
[idc]
Dc Link Current
[IS]
[idc]
DCL
C2F1
Current Measurement1
AC Sourse
A
B
Source Rectifier
Block Parameters: Li-Ion Battery
Battery (mask) (link)
Implements a generic battery model for most popular battery types. Temperature and aging (due to cycling) effects can be specified for Lithium-Ion battery type.
Parameters
Discharge
Type: Lithium-Ion
Temperature
Simulate temperature effects
Aging
Simulate aging effects
Nominal voltage (V) 360
Rated capacity (Ah) 100
Initial state-of-charge (%) 50
Battery response time (s) 10
OK
Cancel
Help
Apply
<Voltage (V)>
<Current (A)>
<SOC (%)>
SOC
P
N
Vehicle Rectifier
Li-Ion B

Simulation :

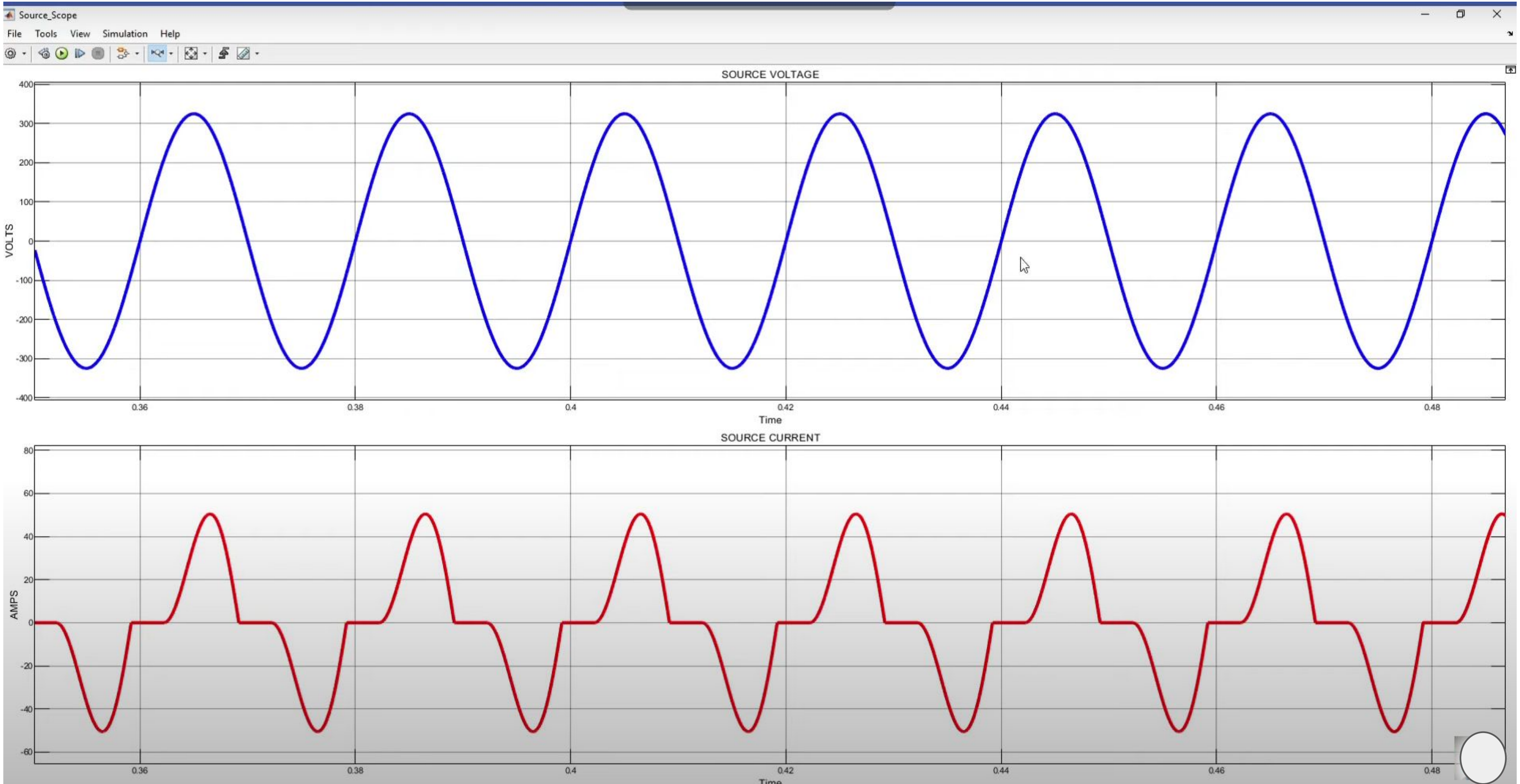


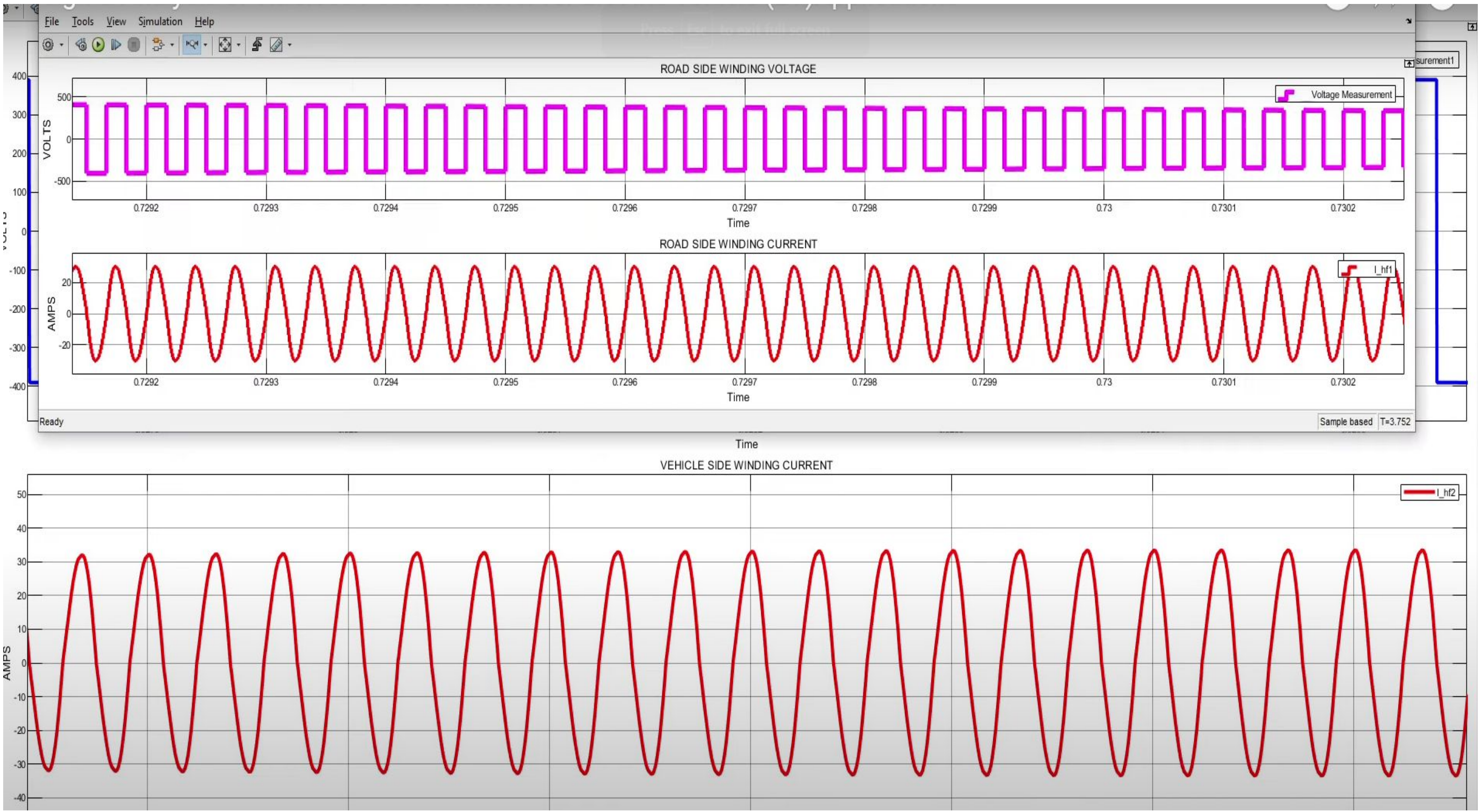
WPT_EV - Simulink academic use
SIMULATION
DEBUG
MODELING
FORMAT
APPS
New
Open
Save
Print
FILE
Library Browser
LIBRARY
Log Signals
Add Viewer
Signal Table
PREPARE
Stop Time
10
Accelerator
Fast Restart
Step Back
Run
Step Forward
Stop
SIMULATE
Data Inspector
Logic Analyzer
Simulation Manager
REVIEW RESULTS
WPT_EV
Wireless Power Transfer for Electric Vehicle Applications
V_Source
Source Current
Source_Scope
Power
Input Reactive Power
Input Active Power
V_DC_Link
Dc Link Current
Mean2
Mean3
DC_Link
DC Link Power
<Voltage (V)>
<Current (A)>
<SOC (%)>
Mean
Mean1
SOC
Bat_Scope
Bat_Input_Power
[Vhf1]
[Vhf2]
I_hf1
I_hf2
[IS]
[idc]
DCL
Current Measurement
Current Measurement1
AC Sourse
"Simscape Electrical" not installed
Source Rectifier
C2F1
HF Inverter
Voltage Measurement
C1
Mutual Inductance
Simscape Electrical not installed
C2
Voltage Measurement1
Vehicle Rectifier
Li-Ion Battery
powergui

Simulation Result:

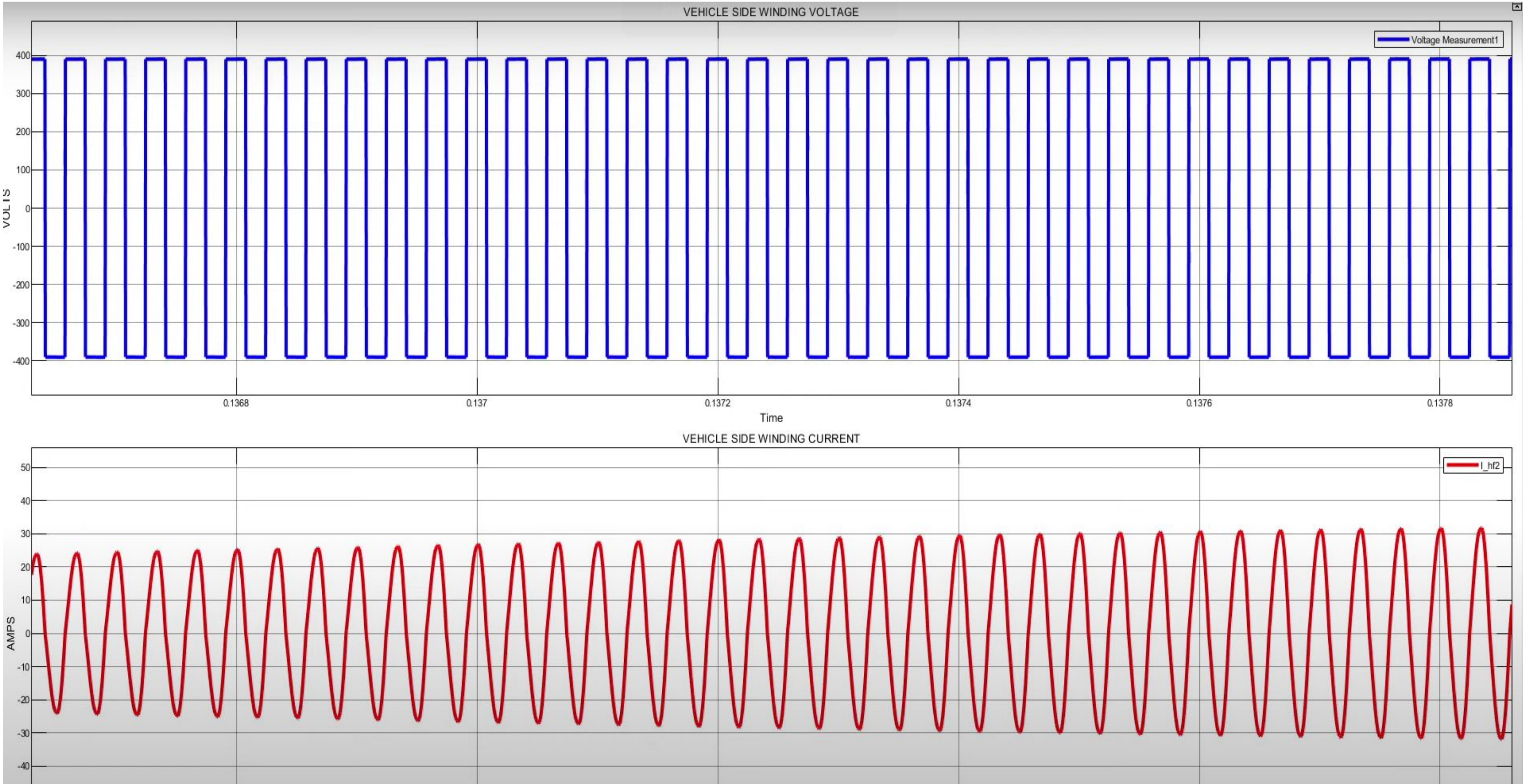


Source voltage:320V
Source current: 50A




File Tools View Simulation Help
ROAD SIDE WINDING VOLTAGE
Voltage Measurement
VOLTS
500
0
-500
0.7292 0.7293 0.7294 0.7295 0.7296 0.7297 0.7298 0.7299 0.73 0.7301 0.7302
Time
ROAD SIDE WINDING CURRENT
I_hf1
AMPS
20
0
-20
0.7292 0.7293 0.7294 0.7295 0.7296 0.7297 0.7298 0.7299 0.73 0.7301 0.7302
Time
Ready
Sample based T=3.752
400 300 200 100 0 -100 -200 -300 -400
surement1
Time
VEHICLE SIDE WINDING CURRENT
I_hf2
AMPS
50 40 30 20 10 0 -10 -20 -30 -40

Vehicle side winding voltage and winding current:



EXPECTED CONCLUSION

The IoT-based wireless vehicle charging station represents a significant advancement in electric vehicle charging infrastructure, offering a comprehensive solution that addresses key challenges and limitations. By incorporating dual spot configuration, app control functionality, power-saving features, and auto-detection technology, the charging station enhances user experience, promotes sustainability, and supports the widespread adoption of electric vehicles. As electric vehicles continue to play a crucial role in reducing carbon emissions and mitigating climate change, innovations like the proposed charging station are essential for facilitating the transition to a cleaner and greener transportation ecosystem.

Thank You